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Collect, connect, upscale: Towards coordinated monitoring of migratory shorebirds in the Asia-Pacific

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ABSTRACT

Monitoring migratory species can be extremely challenging. For example, millions of migratory shorebirds migrate from breeding grounds in northern China, Mongolia and Russia to East Asia and Australasia each year, traversing more than 20 countries while on migration. Studies within individual nations have identified rapid declines in many species, yet progress toward a fully unified scheme for continuous tracking of population change at the scale of the entire East Asian-Australasian Flyway has been slow. To reflect on lessons learned and consider how further progress might be made, we review some of the factors that have limited the full emergence of shorebird monitoring in the East Asian-Australasian Flyway, including fragmentation among multiple databases, low data readiness, inadequate metadata and gaps in survey coverage. We conclude that while technical solutions for many of these issues do exist, the biggest challenge is to navigate the significant organisational, socio-cultural and resourcing contexts of those people doing the monitoring. Technical solutions alone will not create a cohesive network of people whose local efforts are pooled to create robust flyway-scale monitoring.

Key words: monitoring; conservation; shorebirds; East Asian-Australasian Flyway

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Introduction

Tools for monitoring wildlife populations and analysing the resulting large volumes of data have improved rapidly over the last few decades. The emergence and growth of digitally-connected citizen science programs (Catlin-Groves 2012; Dickinson *et al*. 2012), the increased accessibility of complex statistical modelling techniques through free open source software (R Development Core Team 2019), and the low cost of communication in an era of near-ubiquitous internet access have all contributed to a vastly enhanced ability to understand and monitor wildlife populations at local, regional and global levels.

Birds are one of the best-studied taxonomic groups in ecology (Bonnet *et al*. 2002) and conservation (Clark and May 2002). Broad-scale monitoring of bird populations through regular surveys has delivered important outcomes for conservation, such as focusing attention on declining subgroups including Neotropical migratory passerines (James *et al*. 1996), North American grassland birds (Brennan and Kuvlesky 2005), East Asian migratory shorebirds (Amano *et al*. 2010), and European farmland birds (Fuller *et al*. 1995; Donald *et al*. 2006). In all these examples, the existence of large-scale volunteer-driven monitoring datasets paired with analysis by professional researchers and conservation organisations enabled major conservation issues to be identified.

The enormous expansion of citizen science has contributed to the generation of huge volumes of new data on species occurrence and distribution (Bonney *et al*. 2009), none more so than for bird research and conservation. For example, eBird was launched by the Cornell Lab of Ornithology in 2002, and engages a global network of volunteers to collect and submit records of birds using standardised protocols (Sullivan *et al*. 2009; http://ebird.org). All data are freely available and are used by many scientific papers each year (see http://ebird.org/science), and for a number of conservation initiatives. For example,

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Californian eBird data were combined with satellite data to develop predictive models of bird populations and availability of wetlands, and then used to determine temporal and spatial gaps in bird habitat (Reynolds *et al.* 2017). Identified habitat gaps were filled by incentivising landowners to create temporary wetlands on properties with high value bird habitat, with the entire programme being updated as new citizen science data are collected (Reynolds *et al.* 2017). More broadly, eBird records have recently been used to map the status and trends of bird species at a continental-scale across North America (https://ebird.org/science/status-and-trends).

Nonetheless, while comprehensive monitoring of bird populations is relatively tractable in regions with a high density of volunteer birdwatchers (e.g. breeding bird surveys in the USA and UK; Sauer *et al.* 2017, Harris *et al.* 2018), achieving effective monitoring in much of the rest of the world remains a challenge. Many birds have vast geographic distributions, or make seasonal migrations or other less predictable movements over large areas (Newton 2008). Combined efforts by professionals and volunteers are often critical for monitoring abundance and distribution through survey, mark-recapture/resighting and tracking in remote or less-developed regions such as west Africa, the Middle East, northeast China, North Korea and Northwest Australia (Piersma *et al.* 2016, 2017, van Gils *et al.* 2016, de Fouw *et al.* 2017, Riegen *et al.* 2018).

Comprehensive monitoring in a complex world

Analysis of the population trends of widespread or migratory birds requires the collation, curation and interoperability of data from hundreds or even thousands of individual sites and/or observers. One approach to achieving this is centrally-administered programs such as the Breeding Bird Survey in the USA (https://www.pwrc.usgs.gov/bbs) or the Wetland Bird Survey in the UK (https://www.bto.org/volunteer-surveys/webs). Such programs can set data and metadata standards, receive data, rectify errors, curate data in a single central database, and conduct analyses. Yet our world is complex, and such top-down approaches to monitoring become much more difficult when (i) the species being monitored occur across, or move between, multiple countries, and / or (ii) monitoring is conducted by a number of different organisations without any centralised governance mechanism. The European Bird Census Council (http://www.ebcc.info) brings together multiple organisations to conduct the Pan-European Bird Monitoring Scheme, but this is a rare exception and does not yet cover the global geographic range of most European migratory species. These reasons are partly why the concept of 'flyway', a geographic area used to encompass the entire range of migratory waterbird species, was proposed, to (i) represent the complexities of migration in a simple and inclusive geography, (ii) enhance international collaboration and cooperation between countries within the same flyway, and (iii) facilitate the conservation of migratory birds and their habitats (Boere and Stroud 2006).

Here we reflect on how these organisational and scale issues have hindered comprehensive monitoring of migratory shorebirds in the East Asian-Australasian Flyway, a region spanning 22 diverse countries, but as yet with no centralised program of structured bird monitoring at the flyway scale. Recent analyses of monitoring data from relatively small, well-monitored areas of this flyway point to rapid declines in both population size and survival rates in some shorebird species (Amano *et al.* 2010; Clemens *et al.* 2016; Piersma *et al.* 2016; Studds *et al.* 2017). There is now an urgent need to turn these one-off analyses into mechanisms that can continuously track the state of the flyway's shorebird populations. Despite increasing professional and citizen science efforts yielding more and more migratory shorebird monitoring data across the flyway, we currently lack a system to connect these datasets together in a way that permits timely, comprehensive and robust collation of monitoring data. Consequently, we are unable to track the changing impacts of threats on shorebird populations and act accordingly, or to detect the success or failure of conservation initiatives at the population-level. This is hampering conservation efforts, and could potentially lead to extinctions occurring more rapidly than might otherwise be the case. We conclude this discussion paper by outlining some of the critical elements that we believe are needed to move toward a robust and sustainable flyway-wide system of monitoring migratory shorebird numbers.

Migratory shorebirds of the East Asian-Australasian Flyway

Millions of shorebirds migrate each year from their breeding grounds to the coastlines of Asia and Australasia where they spend the non-breeding season (Conklin *et al.* 2014). Recent collation and analyses of high quality monitoring data from Japan, Australia and New Zealand revealed catastrophic declines in the abundance of most species (Amano *et al.* 2010; Clemens *et al.* 2016; Studds *et al.* 2017). These analyses together with elegant mark-recapture / resighting analysis (Piersma *et al.* 2016) confirmed the long-held belief among shorebird experts (professionals and volunteers) that species migrating through the Yellow Sea region of East Asia were declining especially rapidly. This suggested a link with the rapid coastal habitat loss that has occurred in that region in the last 50 years (Murray *et al.* 2014, 2015). Several East Asian migratory shorebird species are now listed as globally threatened, and these analyses have formed a strong scientific basis for understanding how rapidly and for what reasons migratory shorebirds are declining in the East Asian-Australasian Flyway. This allows conservation practitioners and decision makers to formulate management plans to aid population recovery.

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To understand how the scale of future monitoring may need to expand to effectively track migratory shorebird populations throughout the East Asian-Australasian Flyway, we first describe how existing monitoring and analyses came about in Australia, one of the most comprehensively monitored regions in the flyway.

Shorebird monitoring in Australia

In Australia, local systematic shorebird counts began as long ago as the 1950s and 1960s in southern Tasmania (Wall 1953; Thomas 1970). The Royal Australasian Ornithologists' Union launched the National Wader Count in 1981, and monitoring at key sites identified through this project continued through the Australasian Wader Studies Group Population Monitoring Programme, sustained largely by volunteers from the mid-1980s to early 2000s (Wilson 2001; Gosbell and Clemens 2006). Monitoring programs covering specific geographic regions, for example those led by the Queensland Wader Study Group (Milton & Driscoll, 2006) and Hunter Bird Observers' Club (Stuart, 2017) also commenced in the 1990s. Analyses of counts from individual sites were revealing declines in migratory shorebird populations as early as the 1980s, when Close and Newman (1984) noted declines of Eastern Curlew over a 30-year period. Both they and Barter (1993) suggested that land reclamation in China resulting in intertidal habitat loss might be the cause of the decline, and recommended that a national analysis of population trends be performed to form a more complete picture of change in this migratory species.

In 2007, national-scale shorebird monitoring received an injection of funds and energy through BirdLife Australia's Shorebirds 2020 programme, centred on the formation of a national database for Australian shorebird monitoring data. While the shorebird counts themselves were still being carried out largely by volunteer citizen scientists, this framework provided some professional support for coordination and database maintenance (for a more comprehensive history of shorebird monitoring in Australia refer to Hansen *et al.* 2019). This centralisation was a key development that paved the way for national analyses.

Nonetheless, while numerous additional analyses had appeared between the 1980s and early 2000s documenting worrying local and regional population declines of migratory shorebird species (see Hansen 2011 for a review), synthesis of these results was hampered by the lack of capacity for collation and analysis of local data into a national-scale assessment of population trends. As a result, it was not until 2010 that the first national analysis of shorebird population declines was undertaken, fully 50 years after monitoring first began. To achieve a comprehensive national-scale trend analysis, a two-year process of obtaining data sharing permissions and then collating, interpreting, and error-checking data was needed to create a single analysable data file that incorporated the Shorebirds 2020 database as well as databases housed by 13 other organisations (Hansen *et al.* 2019). It is hard to say whether this long delay in connecting the available monitoring data together led to a delay in conservation action, but it is certainly possible.

In addition to the population monitoring through conducting regular surveys, professionals and volunteers also conducted mark-recapture / resighting and tracking projects, in northwest Australia in particular, to monitor the long-term survival, reproductive success and distribution of shorebirds over time (Minton *et al.* 2016; Piersma *et al.* 2016, 2017; Lok *et al.* 2019).

What is clear is that over the last several years, analysis of the monitoring data to reveal trends and identify the causes, has made a contribution (alongside many other factors) to an accelerating international effort to prevent shorebird extinctions and address major threats, particularly habitat loss (eg. see Conklin *et al.* 2014; Gallo-Cajiao 2016; Gallo-Cajiao *et al.* 2017; Melville 2018; Stokstad 2018; Gallo-Cajiao *et al.* 2019). However, it seems plausible that the inability to document widespread shorebird population declines and link these declines to habitat loss earlier represents a missed opportunity to address the escalating shorebird conservation crisis before populations became threatened with extinction.

Challenges in monitoring shorebirds in the East Asian-Australasian Flyway

Although the efforts described above only reflect the Australian situation, there are many additional datasets collating shorebird monitoring information from other countries and regions in the flyway including long-running programmes in New Zealand (Melville and Battley 2006), Japan (Amano *et al.*, 2010) and Taiwan (Lin *et al.* 2018, 2019). Much can be learned from these programmes.

The Taiwan New Year Bird Count (NYBC) is a citizen science project used to monitor the populations of migratory birds in Taiwan and its outlying islands, with extensive coverage of migratory shorebirds. It was launched by the Taiwan Endemic Species Research Institute and various wild bird societies in 2013. Each survey area is a circle with 3 km radius, and a volunteer team chooses one day between mid-December and mid-January to record all the birds detected by sight and sound. In the 2019 survey about 312,000 birds of 325 species were recorded by 1,365 volunteers at 179 sites (Lin *et al.* 2019). To enhance volunteer recruitment and retention, the NYBC team publishes annual reports with results and acknowledgements to the volunteers, and frequently offers feedback to volunteers via social media. Consequently, survey coverage in terms of number of sites and number of volunteers increased between

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2014 and 2019. Over the same time period, concerning declines in the populations of Long-toed Stint *Calidris subminuta* and Common Snipe *Gallinago gallinago* occurred (Lin *et al*. 2019). Setting a leading example to monitoring programmes around the flyway, the full dataset of the NYBC is provided open access on the Taiwan Environment Protection Administration website (https://opendata.epa.gov.tw/). Data are also shared with the International Waterbird Census of Wetlands International (http://iwc.wetlands.org/index.php/). This open approach to data delivery and sharing sets a high standard for others to follow.

Another good example of monitoring with an open approach to data sharing comes from Japan, where shorebird populations have been monitored since the 1970s under three nationwide monitoring schemes, (i) the Annual Census of Shorebirds (1971 - 1999), (ii) the Survey on Population Changes in Shorebirds (2000 - 2003), and (iii) "Monitoring Sites 1000" (2004 – present; Amano *et al*., 2010). In each scheme, surveys are conducted three times a year, in spring, autumn and winter at over 100 survey sites located in the main habitats throughout the country. These monitoring schemes have been coordinated by the Ministry of the Environment, with the aid of conservation organisations, and thus the data collected through these schemes are centralised with reports on summary statistics being published every year (both data and reports in Japanese are available from: http://www.biodic.go.jp/teiten/sigiti/index.html; https://www.biodic.go.jp/moni1000/findings/data/index_file_shorebird.html). One major challenge in Japan has been the lack of quantitative analyses using those long-term data, mainly because such analyses require advanced statistical models to account for common issues in long-term monitoring data, such as large observation errors, missing values and imperfect detection. Nevertheless, there have been a few attempts in the 2000s (Amano, 2006; Amano *et al*., 2010), which revealed severe population declines in Japanese shorebirds. Another issue that has become increasingly important recently is the ageing demographic profile of surveyors, which could impede monitoring efforts in the future (T. Moriya, personal communication).

Other monitoring programmes have also been instrumental in establishing sites of importance; for example a review of the China Coastal Waterbird Census data from 2005-2013 showed that 75 waterbird species occurred in internationally important numbers across 26 sites (Bai *et al*. 2015). The establishment in 1987 by Wetlands International of the Asian Waterbird Census (AWC) has significantly enhanced available information on waterbird populations in the EAAF. The AWC is a volunteer-based monitoring programme coordinated at the country level that generates a snapshot of the distribution and abundance of waterbird species and habitat conditions through once-annual counts at sites throughout East, South, Southeast and Austral-Asian countries. However, uptake of the program has been uneven across countries, and gaps in survey effort, coverage and geospatial description of sites has meant that the generation of population trends for the full suite of waterbird species remains a challenge (Li *et al*., 2009). Flyway-scale assessment of populations relies on collation of country-level monitoring, and many country-level monitoring programs may encounter the same problems as the Australian situation – a limited ability to unite the various datasets regularly so they can be analysed together repeatedly over time (noting the major exceptions for Taiwan and Japan described above), and capacity limitations that hamper maintenance of wide-ranging survey coverage over time. As a result, our ability to develop a truly flyway-scale assessment of shorebird populations, and monitor these continuously enough to be responsive to threats, remains limited.

Achieving flyway-scale monitoring and population assessment is possible and has been tackled elsewhere. Following the listing of the Wadden Sea, one of the most important sites in the East Atlantic flyway (Europe and Africa), as a World Heritage Site in 2009, the Wadden Sea Flyway Initiative was launched. This program recognised the imperative to gather flyway-scale information to assess migratory bird populations. Intensified cooperation spearheaded by Wetlands International and BirdLife International was launched in 2013 to increase coordinated coastal monitoring and, importantly, structured monitoring of environmental conditions and pressures on important bird sites. This effort culminated in the first ever 'total count' of the coastal East Atlantic Flyway in January 2017, which included 33 countries (11 in Europe; 22 in Africa) with funding received from a wide cross-section of organisations (van Roomen *et al*. 2018). This has facilitated a plethora of insights into East Atlantic populations on flyway, regional, national and local levels (see van Roomen *et al* 2018). A full comparative analysis of the factors, leading to successes like these in some flyways compared to the difficulties faced in others, would be very illuminating.

To clarify the current situation in the EAAF and suggest pathways for improvements to flyway-scale monitoring, we have outlined our perspective on some of the challenges that continue to hamper ongoing and responsive population trend analyses to an extent that the conservation of migratory shorebirds in the East Asian-Australasian Flyway remains compromised. As a result of these challenges, assessments of the state of shorebirds in the flyway are currently derived from periodic analyses of relatively limited geographic coverage that appear approximately once per decade, at best.

(i) Fragmentation among multiple databases

Even though regional and national shorebird monitoring databases are being established, many important surveys and monitoring efforts continue to be conducted in isolation and are not accessible in real time through

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any large-scale databases. This means that even when nationwide analyses are required, extensive negotiations are needed to access these data after which an often complicated data management process is required to splice data sources together. Language barriers matter too. Many of the local-scale monitoring data in countries where English is not widely spoken are often managed and available only in local languages (e.g., in Japan and South Korea), making it difficult for international communities to access those data. Furthermore, the lack of consistent data standards for shorebird monitoring means that the spatial and temporal scale of monitoring is often mismatched. This may happen when areas identified during counting are different between surveys due to a change in shorebird behaviour or survey effort (Clemens *et al.* 2014), creating challenges for data unification and in some cases resulting in unusable or discarded data.

In an ideal world, the solution to data fragmentation is to establish data standards for shorebird monitoring, support adoption of these standards and increase the level of interoperability between disjunct databases. In reality, each of these three steps poses its own set of social, methodological and technical challenges. Shorebird monitoring is already reasonably well structured in several countries, but applying data standards consistently across the flyway would require extensive training and ongoing support for survey coordinators. Encouraging adoption of common data standards would require extraordinary amounts of communication, which may necessitate significant institutional support, better engagement of professionals and "train-the-trainer" models of hierarchical engagement. This occurs already to some extent in individual countries, but rolling this out to under-surveyed regions or other countries would require significant and sustained investment of time and resources.

From a technical viewpoint, achieving database interoperability is relatively straightforward if monitoring programs are collecting a relatively standard set of monitoring data. However, the technical ability of monitoring groups is highly variable, and their ability to provision data to other systems (e.g. via web services) is usually limited. This requires establishing mechanisms for data exchange with database systems that have this capacity, requiring resourcing for end users to manage this process.

(ii) Low data readiness

If data are not sufficiently "clean" that an analysis can be performed directly, then significant preparation is required prior to analysis, a process that can take months. The process then needs to be repeated each time an update is needed, unless any changes made during preparation for any particular analysis can be fed back into the contributing database. Such feedback is hampered by the fragmentation issue outlined above.

One practicable way to increase data readiness is a combination of developing common data and metadata standards, and implementing a mechanism for providing feedback or support to end users during the data lodgement and provisioning process. This must be ongoing, as adoption of data standards and data cleaning processes need to be consistent and continuous to be effectual; gaps in funding pose risks to sustained implementation.

(iii) Inadequate metadata

Local monitoring programmes often collect data in different ways based on their capacity, understanding of the local system, and interest in locally-relevant factors. Developing a common metadata standard is one possible solution to improve data readiness for analyses. Arguably there are relatively few pieces of information that are critical to conducting a large-scale population trend analysis: for example a spatial area that is named and georeferenced; an indication of the area actually counted in each visit; the date; and the number of individuals of each species counted. Yet, our experiences of counting birds in the field suggest that a number of additional factors could strongly influence whether an analyst who has never visited a site, or talked to the counters would be able to interpret the data correctly. For example, weather conditions, tidal state, accessibility and the behaviour of shorebirds can vary markedly across surveys; some observers may accept probable identifications of cryptic species while others are more cautious; sites can be destroyed or degraded over time with monitoring efforts ceasing as a result, while in other cases loss of local volunteers results in monitoring gaps. Clearly, extensive discussions would be needed between volunteer groups, data custodians and analysts to reach common ground around minimum requirements for core data fields and for metadata, and to ensure those minimum requirements are fully and consistently recorded.

(iv) Gaps in survey coverage

Significant gaps in survey coverage remain at a flyway scale, particularly across southeast Asia (Gallo-Cajiao *et al.* 2017) and species' breeding ranges, but coverage remains uneven in relatively well-monitored countries like Australia as well (Clemens *et al.* 2012; Hansen *et al.* 2016). This is despite quite widespread volunteering efforts and a number of professionally-run programs (e.g. East Australian Waterbird Surveys; Porter *et al.* 2018), and perhaps reflects the general difficulty of securing funding for either professional or volunteer monitoring. For example, the demographic monitoring conducted by the Global Flyway Network in Australia remains fully funded from outside Australia (see www.teampiersma.org). Nevertheless, robust monitoring programs are emerging in multiple countries where monitoring effort has historically been scarce, suggesting that gaps are closing. In combination with the readily available maps of intertidal habitat (Murray *et al.* 2019), linked monitoring datasets and coordination among local groups would further facilitate identification of remaining gaps in survey coverage across the flyway. With appropriate

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levels of resourcing, significant progress could be made toward filling identified gaps and provisioning such information for broader trends monitoring.

Navigating the social context

Overcoming the technical issues described above is arguably less challenging than working within organisational and social contexts and resource constraints. While professionals have, and continue to contribute toward monitoring efforts (e.g. Piersma *et al.* 2016; Porter *et al.* 2018), large-scale, long-term monitoring is generally reliant on a large base of volunteers. Many of these people contribute large amounts of time and highly developed expertise over sustained periods to local monitoring efforts. Overcoming technical barriers to automated large-scale data collation requires an investment of time and resources by local groups, which is not likely to happen if local groups are struggling to find the resources to conduct activities that are viewed locally as higher priorities. Providing services such as automated local-scale reporting and data management tools and resources to assist with local count programs or research could help to address barriers to participation, but also requires funding and resources that may be difficult to source.

A critical part of any solution will be to ask those people actually collecting the data what they want from the process, and find a way of providing those things. This could relate, for example, to shared database structures, automated reporting for local areas as data come in, resources to conduct counts for the next ten years, resources to coordinate counts or handle data, or resources to explore research questions independently. Providing customised access for local groups to spatial information systems that are built upon a centralised database might help build bridges rather than walls. Ultimately, while meeting local groups' needs is critical to maintaining an area's monitoring effort, a lack of capacity or interest from participating volunteers in data standards may require paid database administration that can work to gather and clean collected data that meets agreed standards. Another solution might be something like the system used in the PanEuropean Common Bird Monitoring Scheme, where data quality control is first implemented and population indices are developed at the national level, then the estimated indices are combined at the supranational level (https://pecbms.info/methods/pecbms-methods). Nonetheless, the willingness of large numbers of volunteers from across the flyway to participate in the annual Asian Waterbird Census (https://south-asia.wetlands.org/our-approach/healthy-wetland-nature/asian-waterbird-census) and the uptake of citizen science programs in the region signal a widespread recognition of the need for achieving regular wide-scale monitoring.

The future of shorebird monitoring in the East Asian-Australasian Flyway

The emergence of the East Asian-Australasian Flyway Partnership has created a highly coherent and functional forum for international communication and cooperation among countries, intergovernmental agencies, international non-governmental organisations and private enterprise (Gallo-Cajiao *et al.* 2019; http://www.eaaflyway.net). The Partnership is catalysing conservation action around the flyway, serves as a platform for efficient communication, and has indeed identified many of the issues that we have raised already, for example through the establishment of a monitoring task force. It seems logical to us that the Partnership and its associated entities would have a central role in any flyway-wide monitoring effort. Indeed, the establishment of a 'Monitoring of waterbird populations and sites' Task Force in 2010 (https://www.eaaflyway.net/project/monitoring-of-waterbird-populations-and-sites-task-force), the recent establishment of a flyway-scale Science Unit based in China, and the decision at the 10th East Asian Australian Flyway Partnership meeting to "establish a systematic process to maintain up-to-date information on all waterbird population estimates, trends and 1% thresholds through the preparation of a periodic EAAF Conservation Status Review" (https://www.eaaflyway.net/about-us/the-partnership/partners/meetings-of-partners/10th-meeting-of-partners-mop-10/document DD.12) all signal a wide-ranging aspiration to achieve robust flyway-scale population and habitat assessments through the auspices of the partnership.

Historically, bird monitoring has struggled to scale up to the geographic reality of birds' distribution or migration pathways. Our brief review suggests that the need to address the technical and capacity issues associated with monitoring birds that traverse the flyway's highly diverse countries has never been greater, but that significant organisational, social-cultural and resourcing contexts need to be navigated before regular, comprehensive flyway-scale analyses will be achievable. Technical solutions alone will not create a cohesive network of people whose local efforts are translated regularly into robust and reliable flyway-scale analyses. Solutions to improve monitoring must involve communication, collaboration, and build on the shared sense of purpose. Equally important is resourcing to support improved communication, collaboration and continuous monitoring effort in critical but remote shorebird areas with low density of volunteer birdwatchers. We strongly feel that finding such solutions is imperative if the steep population declines of the last several decades are to be halted and extinctions of our flyway's awe-inspiring long-distance migratory shorebirds are to be averted.

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